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Capabilities of Dating of Glazed Ceramics with Monochrome Glaze

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***Abstract**:*

Excavations of Kazan Kremlin conducted in 1994-2005 yielded diverse material in the form of numerous fragments of monochrome glazed ceramics. The fragments of glazed dishware originate from layers dating back to various epochs starting with the Kazan Khanate and ending with the Post Medieval period.

This article is concerned with the research of the chemical composition of the glaze and paste of ceramics dating back to the late Middle Ages. Natural scientific research has allowed to identify two primary types of glass-forming components - sodium and lead. Groups differing in the elemental composition of paste and glaze were identified as a result of statistical processing of the analytical data.

This distribution significantly corresponds to dating of artefacts on the basis of their stratigraphic chronology and comparative morphological analysis. A comparison of the obtained materials allows to identify samples of glazed ceramics from the excavations of Kazan Kremlin with unknown or speculative dating.

***Keywords:** Archaeology, Kazan Khanate, Glazed Ceramics, Chemical Analysis, Dating*.

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1. Introduction

Among the items discovered at archaeological excavations of Kazan Kremlin conducted in 1994-2005 was glazed ceramics from strata dating back to various time periods, including Kazan Khanate (Kalinin, 1953; 1954; 1958; Koval, 2015; Sitdikov, 2006). Such findings are familiar to researchers as a result of investigations conducted in Kazan Kremlin, and they are also available in collections from the excavation of synchronous sites located in the Volga-Kama region (Kokorina, 1995; 1999; Fakhrutdinov, 1999). Materials associated with stratifications of the Kazan Khanate period were a subject of independent research (Koval, 2008; Sitdikov, 2001). Ceramics of a later period was discovered at the excavation of a Post-Medieval glass workshop (Khramchenkova, Sitdikov and Kaisin, 2016).

A special place among the discovered glazed ceramic artefacts belongs to monochrome glazed ceramics with turquoise, green and brown glaze made of red and white clay. A total of 107 samples of this type of glazed ceramics were discovered as a result of the studies (Sitdikov and Kharchenkova, 2011). Many artefacts, particularly those with green glaze, are very similar in terms of the manufacturing technology, although they have originated from stratigraphic layers with a 200-400 year difference in dating. The fragments can only be distinguished by morphological features, but some of the findings are unfortunately of a very small size, which makes it impossible to determine the shape of ceramic dishware. Another challenging issue is the accurate dating of the fragments. It is caused by the numerous fires which have occurred in Kazan over the past centuries. The subsequent development of the burnt Kremlin territories was conducted with complete removal of cultural layers.

The analytical data provide researchers with a tool for objective evaluation of archaeological material. The characteristics of the glaze formulation of certain samples have been previously studied (Khramchenkova, 2011; Sitdikov and Khramchenkova, 2015). The article considers a study of the chemical composition of the glaze and ceramic paste belonging to all types of monochrome glazed ceramics discovered in the course of excavations at Kazan Kremlin. Selected samples taken from chronologically stratified layers give an opportunity to study the variations of ceramic formulations and determine the technological characteristics of the articles. An analysis of elemental composition allowed to identify groups of 16th-18th century glazed ceramics with various chemical composition of glaze and paste correlating with the time intervals established on the basis of stratigraphy.

2. Materials

The findings have been collected at 22 excavations of Kazan Kremlin. Fragments of ceramics with different colours of clay and glaze corresponding to various stratigraphic layers were selected for analysis. Due to the fact that a portion of the archaeological material does not allow to collect representative sample weights, a total of 48 fragments were included in the research sample. It should be noted that a portion

of the findings are fragments of several of vessels, and therefore only individual samples of the corresponding vessels were collected for analysis.

Table 1 (Appendix A) features a stratigraphic and morphological description of the findings with their chemical composition studied in this work. The findings were dated on the basis of the stratigraphic scale of Kazan Kremlin (Sitdikov, 2006).

The studied artefacts belong to three archaeological horizons. Five samples of glazed ceramics originate from the upper horizons of layer 4 (second half of 13th - first half of 15th centuries). A half of them (24 samples) come from a layer formed during the period of Kazan Khanate (first half of 15th - second half of 16th centuries). Six findings were discovered in horizons formed after the Khanate period. Eleven fragments were taken in the lower horizons of the layer 2 (second half of 16th – 18th centuries). A single specimen of ceramics, similar to findings from the Kazan Khanate layer, was discovered in the late horizons of the Golden Horde period. A single fragment is not stratigraphically bound, which complicates its identification.

3. Chemical Composition

The chemical composition of the ceramic paste and glaze was determined using the optical emission spectroscopy technique. The OES technique is described in several sources (Khramchenkova *et al.,* 2017). As mentioned above, fragments from different stratigraphic layers and morphological groups were selected for the study, 48 fragments of glazed ceramics were studied in total. Fragments of the ceramic base weighing 50-60 mg were taken from each sample. Because the glazed layer of ceramics is rather thin on all the fragments, the glaze was collection using a diamond broach file to avoid contamination with the clay base.

The results of chemical composition studies are presented in Table 2 (Appendix B). Because of the large amount of numerical information, the table only includes elements which served as markers during classification. The primary distribution is accounted for by the glass-forming components - sodium and lead (for simplicity reasons, the subsequent description of chemical characteristics will not contain the word 'oxide').

During statistical processing the concentration of copper and iron in the glaze was not considered, as these elements are responsible for the coloring of the glaze. Adding copper to the glazing solution provided blue, turquoise or brilliant green colors, the dark brown color was obtained by means of high iron content, and green, olive or light brown colors were provided using various compounds of this element with oxygen (suboxide, dioxide) (Chaldek, Sova and Truglarzovski, 1990).

According to analysis results, all fragments were classified into fourteen groups (Table 2). As seen from the results, two groups of supposedly imported ceramics featuring glaze with a high constitute are at the top. Two samples - fragments of a tile

and bottom of a light-blue vessel, contain pure sodium glaze and constitute the first group. Given the low percentage of potassium, one can assume soda glazing. The second group of glazes consists of a sodium, lead and tin mixture containing theses components in various proportions. The glaze of both groups is characterized by a high lithium content.

The third group contains a sample of imported ceramics with glaze allegedly consisting of lead and tin. A single sample with lead glaze constitutes the fourth group. The ceramic basis of these findings is characterized by a low aluminium content similarly to the first group. The paste of the third group is characterized by a very high calcium content of 20%, and the glaze of the fourth group - by an increased phosphorus content of 4,56%.

The fifth group includes artefacts with lead glazing, also featuring high concentrations of the phosphorus component, but unlike the fourth group, the findings were composed of clay with a high aluminum and arsenic content.

Ceramics of the sixth group are characterized by a low aluminum content and high values of calcium 6-7.5%, and the glaze of this ceramics is characterized by low phosphorus concentrations. This clay has net been encountered in any other groups. Lead content in the seventh, eighth and ninth groups amounts to 20-36%. High titanium and beryllium content is characteristic of the glaze of the seventh group, and the samples of the eighth and ninth groups are almost identical except for high iron content in the clay of the ninth group. The ninth group is characterized by a considerable presence of tin from 1 to 5% and phosphorus, in addition to high lead content. Concentration of the lead component in the glaze of the following groups exceeds 42%.

Low phosphorus content in the glaze and high iron concentrations in the paste are a distinctive feature of the tenth group. The eleventh and twelfth groups differ in the calcium and phosphorus content in the glaze (in the eleventh group the content P_2O_5 is considerably less than in the twelfth) and less iron content in the clay. Findings of the thirteenth group are distinguished by a very low concentration of phosphorus, which does not exceed 0.2%, whereas the ceramics of the fourteenth group is composed of clay with a low aluminum content.

4. Discussion

Statistical processing of data on the contents of glaze and paste has revealed a total of 14 groups. Each group features a characteristic chemical composition of both irrigation ceramics components. As mentioned above, the content of copper and iron in the glaze was not considered during processing, as these elements were added to glaze solution to impart color. It should also be noted that the color of ceramic paste is determined by the firing mode and depends on whether an oxidation or reducing reaction has occurred. The nature of the variations in the final coloring of ceramics

composed of identically colored clay has not been thoroughly studied (Yatsenko, 2015). According to some researchers (Avgustinik, 1975; Krupa and Gorodov, 1990), during firing in a reducing environment, iron dioxide which imparts the red color is transformed into white and yellow minerals (felite). Studies conducted by Yatsenko (2015) demonstrated that the color of ceramics depends on the presence of hematite, which is actively formed in an oxidizing environment. The presence of variously colored ceramics fragments in the groups can be explained by the very firing of products composed of identical clay conducted in different modes.

As demonstrated by the results of chemical analysis, all products with obvious import characteristics are classified into separate groups (Table 2). These are groups 1-3 (Fig. 2-4) with a sodium, sodium-lead-tin or lead-tin glaze formulation. Most of the samples originate from layers 3-4. Considering the difference in the glaze color accounted for by the presence of copper in the case of the light-blue color and an increased iron content in the case of the brown color, samples from a single group have a practically identical chemical composition of both glaze and ceramic paste. This indicates the same sources of raw material for glaze and paste. Therefore, in can be assumed that the ceramics of each group was produced in specific workshops located near each other.

The glaze of other fragments of imported ceramics with a higher lead content (31-41%) contains tin similarly to the samples of the second and third groups, i.e. this element can serve as an indicator of the foreign origin of the items. As noted in written sources (Khramchenkova, 2011), the presence of tin in lead glaze was characteristic of medieval Iranian and Turkish products from late medieval Muslim production centres (Koval, 2010).

As demonstrated by stratigraphic analysis, the last two groups originate from layers 2 and 2-3. They are quite similar in terms of their morphological characteristics and chemical composition. These groups feature indicators which are completely different from the other groups. Group 14 is characterized by a low aluminum content in the paste and high lead content in the glaze. In view of the morphological assessment and the fact that ceramics from this group originates from the upper layers, all findings with such indicators can be dated 18th century. Considering the composition of glaze from the thirteenth group, it features a very low phosphorus concentration. It should be noted that the glaze of almost all samples dated 18th century because of their external appearance is characterized by a low content of this element. It can be assumed that the ceramics from these groups was produced at a single site, but in a certain period the source of raw material for ceramic clay was changed.

5. Conclusions

The traditions of glazed ceramics with coloured glaze in Muslim countries produced in the Middle Ages in the territory of Iran, Syria and Turkey, established and

developed in numerous workshops which manufactured large amounts of dishware with green lead glaze). These types of ceramics include samples from Kazan.

The conducted studies demonstrated that the technology of producing ceramic glaze from the excavations of Kazan Kremlin is identical to the Turkish and Crimean technology. The glaze was produced from a mixture of lead and a sandy clay in various proportions from 2:1 to 1:3. According to analytical data (Gulmini *et al.*, 2013), a low aluminum content is observed in the glaze of Afghan samples. In Italian samples, the concentration of this element is 4-7% (Maltoni *et al.*, 2012), same as in Kazan, Turkish and Crimean items.

Another possible conclusion in the almost complete similarity of the chemical composition of glaze and paste within the groups, including samples with different glaze colors. This have explained using raw material from identical sources for the production of ceramics, whereas the color palette was determined by color reagents - iron and copper - for the glaze, and by the firing mode for the paste.

In conclusion, it should be noted that dating because of morphological features and microscopic analysis only does not provide accurate results. It also applies to stratigraphy in cases when the layers could have been mixed because of repeated reconstructions and the associated cleaning of the territory, as was the case in Kazan Kremlin. The studies described in this work demonstrated a complete agreement of classification into groups based on the chemical composition of glaze and the ceramic paste with the dating established with the consideration of stratigraphy and morphology. Thus, having analytical data on the concentrations of elements is it became possible to conduct more accurate dating of glazed ceramics from Kazan Kremlin with more probability.

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Appendix A:

Table 1: *Stratigraphic and morphological description of the studied samples of glazed ceramics discovered in Kazan Kremlin.*

#	Group	Name of the Item	Base	Glaze	Excavation No.	Code	Finding Location	Fig.
1.	1	Tile fragment	white clay	light blue	KK.04-LII	798	Adit 23 build. 50 layer III	3.1
2.	1	Bottom fragment	white clay	light blue	KK.98-XIII	387	Adit 11 sect. V/13 depth 220 layer 3 (4 (?))	3.2
3.	2	Vessel fragment	red clay	light blue	KK.00-XXXIV	2838	Adit 3 sect. D/13 layer 4	4.5
4.	2	Vessel fragment	red clay	light blue	KK.00-XXXVII	50	layer 2	4.4
5.	2	Vessel fragment	white clay	brown	KK.01-XLIII	478	Г/3, adit 2, layer 4 (3?)	4.1
6.	2	Near-bottom section fragment	red clay	light blue	KK.97-IX	431	Adit 13 sect. B/7 layer 2-3	4.1
7.	2	Handle fragment	red clay	light blue	KK.98-X	348	Adit 5 sect. Г/13 depth 100 layer 2-3	4.3
8.	3	Vessel neck fragment	white clay	brown	KK.98-XIII	235	Adit 10 sect. G/11 depth 200 layer 3	5.1
9.	4	Vessel fragment	red clay	green	KK.01-XLIIIб	268	Pcs. 15 G/24 layer 3 (4 (?))	6.1
10.	5	Wall fragment	red clay	yellow	KK.00-XXXIV	2477	Build. 50, select. 2, layer 4	7.1
11.	5	Wall fragment	red clay	green	KK.01-XLIII	273	sect. G/23, adit 8, layer 2	7.4
12.	5	Wall fragment	red clay	green	KK.01-XLIII	292	sect. V/22, adit 14, layer 3 (4)	7.3
13.	5	Wall fragment	red clay	green	KK.97-X	70	Sect. A,B/5, layer 2-3(?)	7.2
14.	6	Neck fragment	red clay	green	KK.96-VII	338	Sect. Zh/3-8, build. 9, select. 1,2, layer 2	8.2
15.	6	Vessel wall fragments	red clay	green	KK.97-IX	787, 788	Build. 46 select. 1 layer 3	8.3
16.	6	Ceramics fragment	red clay	green	KK.98-XIII	403	Adit 10 sect. V/10 layer (?)	8.1

17.	7	Vessel fragment	white clay	green	KK.00-XXXIV	1501	Build. 23, select. 1, layer 3	9.1
18.	7	Vessel fragment	grey (burnt)	green	KK.01-XLVIII	1	Layer 1-3	9.3
19.	7	Water carrier fragment	red clay	green	KK.98-XXII	42	Build. 6, depth 55, layer 3(?)	9.2
20.	8	Neck fragment	white clay	green	KK.01-XLVI	58		10.2
21.	8	Vessel handle	white clay	green	KK.05-LXVa	49	Sect. A,B/4,5 build. 4 layer 4	10.3
22.	8	Ceramics fragment	white clay	brown	KK.97-IX	38	Adit 16 dist. B/6 layer 2	10.4
23.	8	Vessel fragments	white clay	green	KK.97-IX	703	Build. 9 adit 11 select. 1 sect. A/14 layer 2	10.5
24.	8	Neck fragment	white clay	green	KK.98-XIII	43	Adit 18 sect. A/8 depth 360 layer 4 (?)	10.1
25.	9	Ceramics fragment	red clay	brown	KK.98-XIII	329	Adit 13 sect. B/7 depth 260 layer 3	11.1
26.	10	Vessel wall	red clay	green	KK.03-LIIIa	480	Adit 12 sect. -1/Z layer 3	12.1
27.	10	Near-bottom section fragment	red clay	green	KK.97-II	137	Adit 8 sect. N/13 layer. 2-3 (?)	12.2
28.	10	Vessel wall fragment	red clay	green	KK.98-XIII	236	Adit 16 sect. A/12 depth 320 layer 3	12.3
29.	11	Bottom fragment	white clay	green	KK.00-XXXIV	185	B/9, adit 2, layer 3	13.3
30.	11	Vessel bottom fragment	white clay	green	KK.95-III	19	Adit 2 dist. V/3, layer 2	13. 1
31.	11	Water carrier fragment	red clay	green	KK.98-X	266	Adit 8 sect. D/7 layer 4-5 (?) subsoil	13.2
32.	12	Kumgan spout	white clay	green				14.7
33.	12	Nose fragment	white clay	brown	KK.01-XLVI	3		14.3
34.	12	Vessel wall	white clay	green	KK.04-LII	376	Adit 20 sect. E/20 layer 3	14.2
35.	12	Vessel bottom	white clay	green	KK.04-LXIII a	647	Sect. B,V/4,5. Adit 15. layer 2, build. 10.	14.5

36.	12	Vessel fragments	white clay	green	KK.94	1385	layer 2-3	14.4
37.	12	Neck (pottery)	white clay	brown	KK.94	932	Pit 13 select. 1 depth 360, layer 3	14.6
38.	12	Neck fragment	white clay	green	KK.95-III	2000	Western build. 16, dist. B/2, layer 2	14.1
39.	13	Bottom fragment	white clay	green	KK.00-XXXVII	137	layer 2	15.5
40.	13	Vessel wall	white clay	green	KK.04-LXIIIб	535	Sect. A'-A/5 adit 1,2, layer 1	15.3
41.	13	Russian vessel fragment	white clay	green	KK.94	1264	Adit 4, layer 2	15. 1
42.	13	Vessel wall fragment	white clay	brown	KK.96-II	414	Depth 380 sect. K/23	15.2
43.	13	Vessel bottom fragment	white clay	green	KK.97-XII	105	Adit 14 layer 2-3, sect. A,B,V,-A',B',V'/9	15.4
44.	14	Vessel wall fragment	white clay	green	KK.00-XXXVII	311	layer 2	16.1
45.	14	Vessel wall	white clay	green	KK.04-LVв	47	Adit 25 (4) sect. V/3 layer 2	16.3
46.	14	Vessel fragment	white clay	brown	KK.04-LXIV(2)	261	Adit 13 sect. E,Zh/1,2	16.5
47.	14	Vessel wall fragment	white clay	green	KK.96-II	467	Depth 340 sect. Z,I/22 layer 2	16.4
48.	14	Vessel wall fragment	white clay	brown	KK.97-IX	461	Adit 10 sect. V/3 layer 2-3	16.2

Appendix B.

Table 2: *Chemical composition of the glaze and ceramic paste of glazed ceramics fragments from Kazan Kremlin. The concentration of oxides is given in %, and microimpurities – in ppm.*

			glaze											biscuit									
#	**group**		**PbO**	**SnO**	**TiO_2**	**P_2O_5**	**CaO**	**Fe_2O_3**	**Na_2O**	**As**	**B**	**Be**	**Li**	**TiO_2**	**P_2O_5**	**CaO**	**Fe_2O_3**	**Al_2O_3**	**K_2O**	**Sc**	**V**	**layer**	**number in figures**
1		**КК04-LII № 798**	0,34	2,16	0,27	0,3	2,06	0,11	**12,2**	16	31	0,8	**45**	**0,2**	0,23	1,13	0,19	**1,98**	1,25	**0**	**2**	III	
2	1	**КК98-XIII № 387**	1,98	1,18	0,39	0,34	5,09	0,58	**13,9**	12	**2800**	1,4	**65**	**0,4**	4,12	5,23	0,87	**18,34**	2,32	**0**	**1**	III (IV (?)	3
1		**КК01-XLIII /478**	9,63	**4,97**	0,71	0,92	8,41	1,16	**10,9**	83	73	1,5	**51**	1,49	0,044	1,52	7,86	**22,57**	1,11	1,8	11	IV(III?)	
2		**КК97-IX № 431**	15,98	**3,79**	0,33	0,54	4,31	0,18	**5,56**	51	45	0,8	**85**	1,24	0,082	2,16	7,18	**33,85**	1,25	1,8	21	II-III	
3		**КК98-X /348**	5,01	**5,02**	0,69	0,41	2,89	1,53	**11,8**	85	71	2,1	**52**	1,06	0,14	1,2	5,62	**32,23**	1,42	1,6	13	II-III	
4		**КК00-XXXVII №50**	18,57	**1,28**	0,17	0,14	3,45	0,76	**5,97**	14	48	0,6	**150**	0,77	0,13	1,25	7,72	**39,68**	1,27	2,2	21	II	
5	2	**КК00-XXXIV/2838**	7,69	**7,23**	0,4	0,57	6,41	1,35	**15**	94	210	1,1	**62**	1,27	0,55	0,97	4,58	**30,57**	1,58	1,9	39	IV	4
1	3	**КК98-XIII № 235**	15,46	**5,53**	0,31	0,97	4,76	0,62	1,34	**190**	25	1,4	32	0,91	**4,27**	**20**	4,29	**16,32**	0,38	1,1	6	III	5
1	4	**КК01-XLIII-Б /268**	9,83	0,11	0,68	**4,6**	2,79	**8,3**	0,32	43	23	2,9	25	0,96	**3,15**	2,33	5,15	**15,59**	3,36	1,3	11	III (IV (?))	6
1		**КК00-XXXIV/2477**	14,92	0,47	0,22	**2,6**	0,69	0,91	0,16	**170**	**8,9**	1,3	22	1,35	0,13	1,14	4,72	31,16	0,89	1,6	17	IV	
2		**КК97-X/70**	12,71	0,026	0,21	**1,1**	1,38	1,37	0,13	27	17	1,6	22	0,7	0,17	1,38	5,59	34,82	0,58	1,2	8	II-III(?)	
3		**КК01-XLIII/292**	24,37	1,78	0,18	**5,2**	2,14	1,73	0,16	76	**9,5**	1,4	21	0,87	0,53	1,66	6,44	28,79	0,73	1,4	11	III(IV)	
4	5	**КК01-XLIII/273**	9,16	0,74	0,38	**3,4**	2,33	1,35	0,53	**190**	**5,3**	1,1	23	0,99	0,38	1,52	7,08	28,35	1,13	1,4	15	II	7
1	6	**КК98-XIII № 403**	24,12	0,16	0,52	0,14	3,68	1,43	0,51	20	140	1,8	26	1,19	0,87	**6,5**	4,42	**18,29**	1,67	1,5	13		8

2		**KK96-VII/338**	23,78	0,64	0,29	0,16	0,76	2,64	0,25	36	41	1,5	31	1,09	0,16	**5,9**	6,73	**18,56**	0,56	1,1	**3**	II	
3		**KK97-IX № 787,788**	12,02	0,11	0,46	0,15	1,17	0,74	0,74	7	33	1,6	24	1,27	0,66	**7,4**	4,86	**17,23**	1,72	1,9	20	III	
1		**KK00-XXXIV/1501**	30,52	0,039	**1,5**	1,49	1,61	1,24	0,22	89	78	**4**	28	1,26	1,32	2,57	0,74	27,89	1,75	1,8	16	III	
2		**KK98-XXII /42**	20,16	0,067	**1**	0,87	1,74	1,06	0,49	32	65	**4**	35	1,19	0,66	1,14	4,58	23,67	0,86	1,3	20	III(?)	
3	7	**KK01-XLVIII /1**	25,18	0,11	**1**	0,25	1,42	1,72	0,46	34	180	**4**	28	1,67	0,29	0,81	1,72	23,19	0,67	1,3	29	I-III	9
1		**KK98-XIII № 43**	35,95	9E-04	0,24	0,24	0,26	1,34	0,075	3	21	1,4	35	1,64	0,37	0,92	0,89	22,68	0,78	1,6	32	IV (?)	
2		**KK01-XLVI № 58**	29,7	0,065	0,32	0,39	0,48	0,22	0,4	11	48	1,1	25	0,79	0,038	0,71	0,92	30,24	0,66	1,8	26		
3		**KK05-LXV A № 49**	33,58	0,004	0,36	0,17	0,79	1,28	0,42	90	46	1,5	25	0,86	0,068	0,55	0,59	26,48	0,39	1,5	19	IV	
4		**KK97-IX № 38**	36,42	0,24	0,27	0,04	0,94	3,29	0,23	25	43	1,7	27	1,42	0,81	0,96	0,85	37,83	0,58	1,8	20	II	
5	8	**KK97-IX № 703**	36,64	0,035	0,24	0,98	0,97	0,38	0,36	16	39	1,6	31	1,23	0,077	2,48	0,83	43,46	0,41	2,3	12	II	10
1	9	**KK98-XIII № 329**	32,4	5E-04	0,28	0,06	0,63	1,27	0,59	7	62	1,6	29	1,09	0,12	1,22	**4**	19,03	**1,3**	1,6	20	III	11
1		**KK03-LIII A № 480**	41,16	**5,23**	0,24	**1,2**	0,65	0,72	0,55	7	19	0,9	26	0,64	1,63	1,06	**4,2**	24,58	**0,8**	1,4	18	III	
2		**KK97-II № 137**	31,64	**1,08**	0,3	**1,7**	2,84	1,41	0,3	21	59	1,8	31	1,35	0,64	1,49	**4,2**	24,55	**1,8**	2,4	24	II-III (?)	
3	10	**KK98-XIII № 236**	41,12	**1,35**	0,34	**0,5**	0,42	0,77	0,33	46	29	1,4	24	1,37	0,052	1,58	**4,5**	21,36	**1,2**	2,5	16	III	12
1		**KK95-III/19**	49,24	0,046	0,55	**3,2**	**1,9**	3,74	0,32	19	61	4,4	38	0,79	1,53	2,46	**9,3**	28,12	2,03	1,7	21	II	
2		**KK98-X /266**	45,31	0,057	0,55	**4,4**	**1,5**	1,17	0,46	21	61	4,8	25	1,11	4,24	2,05	**4,6**	28,84	0,59	1,2	14	IV-V (?)	
3	11	**KK00-XXXIV/185**	44,89	0,031	1,27	**1**	**1,5**	1,07	0,45	24	62	2,8	26	1,86	0,44	1,26	1,18	20,53	0,54	1,1	18	III	13
1		**KK95-III/2000**	54,87	0,13	0,16	0,79	0,23	1,51	0,096	48	18	1	25	1,15	0,87	0,76	0,32	39,68	0,51	0,6	13	II	
2	12	**KK04-LII № 376**	53,48	0,008	0,39	0,57	0,82	0,69	0,25	2	35	1,6	29	1,54	1,03	1,48	2,42	34,19	0,61	2,2	46	III	14

3		**КК01-LXVI № 3**	49,27	0,011	0,26	0,37	0,61	6,68	0,043	2	13	1	32	1,54	2,75	2,23	1,86	40,64	0,53	2,8	45		
4		**КК94 № 1385**	59,4	0,006	0,35	0,21	0,3	0,27	0,16	38	21	1,4	22	0,89	4,75	1,73	0,46	30,24	0,35	1,3	47	II-III	
5		**КК04-LXIIIA/647**	59,96	0,31	0,27	0,32	0,59	1,65	0,13	21	48	1,7	23	1,05	0,34	1,09	1,37	35,73	0,51	2	28	II	
6		**КК 932**	42,12	0,004	0,25	0,41	0,77	4,43	0,36	16	31	1,3	26	1,14	0,33	1,04	3,15	34,02	0,42	1,3	14	III	
7		**SM**	46,52	0,025	0,48	0,25	0,72	0,51	0,49	39	24	1,4	24	1,22	1,79	2,85	2,57	34,73	0,46	1,2	14		
1		**КК94-/1264**	41,98	0,056	0,15	**0,1**	0,29	1,3	0,084	16	84	1,4	27	1,3	0,65	1,32	3,15	36,18	0,39	2,5	27	II	
2		**КК96-II № 414**	45,36	0,006	0,37	**0,1**	0,56	3,58	0,34	5	43	1,2	27	1,62	0,53	0,95	0,82	39,65	0,37	1,9	33		
3		**КК04-LXIII Б № 535**	51,02	0,033	0,31	**0,1**	0,34	0,43	0,23	8	59	1,5	38	1,45	0,37	0,74	0,86	28,35	0,49	1,9	18	I	
4		**КК99-XII № 105**	44,81	0,018	0,47	**0,1**	0,7	0,76	0,26	16	28	1,6	41	1,3	0,087	0,73	1,29	34,26	0,53	1,2	12	II-III	
5	13	**КК00-XXXVII №137**	49,29	0,056	0,34	**0,2**	0,35	0,48	0,12	14	41	1,1	26	1,05	0,11	0,75	0,69	39,67	0,84	1,6	34	II	
1		**КК00-XXXVII №311**	51,44	0,013	0,28	0,36	0,22	0,28	0,036	19	46	1,4	23	1,19	1,53	0,98	0,97	**18,69**	0,37	1,3	17	II	
2		**КК97-IX № 461**	48,06	0,007	0,4	**0,1**	0,24	3,77	0,32	14	36	1	28	0,69	0,11	0,39	0,69	**20,95**	0,23	1	14	II-III	15
3		**КК04-LV B № 47**	49,86	0,016	0,38	**0**	0,42	1,05	0,26	5	54	1,1	25	0,65	0,89	0,81	0,43	**20,79**	0,46	1,3	14	II	
4		**КК96-II № 467**	38,88	0,028	0,3	0,44	0,42	0,5	0,19	4	31	1,1	27	0,82	1,67	0,96	0,87	**18,83**	0,45	1,9	34	II	
5	14	**КК04-LXV 2 № 261**	43,28	0,046	0,35	0,28	0,56	4,58	0,14	13	58	1,7	21	1,15	0,78	0,67	0,72	**19,36**	0,42	2,7	19		16